

A mathematical account of marine corrosion behaviour of galvanised steel structures installed in Digha coast of Bay of Bengal

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An approximate mathematical equation in terms of atmospheric chloride count, C (mg/m²/day) and the average rainfall, R_f (mm/day) to evaluate marine corrosion rate of galvanised structures and installations is attempted. Mathematical relationship giving thickness-loss, TL , due to marine corrosion of galvanised steel installations at the Digha coast of the Bay of Bengal has been worked out to be $TL = 1.086 \times 10^{-2} \times C \times R_f$.

The hot galvanised zinc coatings have been used for many years to protect steel from atmospheric corrosion in all applications that require atmospheric corrosion protection of steel. Coating serves as a barrier and the zinc contained in the galvanised coating provides galvanic protection. The galvanised zinc coating cathodically protects the underlying steel at scratches, cuts, and other breaks in the coating¹. The zinc coating/galvanised steel on atmospheric exposure first forms non-protective zinc hydroxide, which on reaction with CO₂ present in the atmosphere converts to protective zinc carbonate hydroxide. The formation of zinc carbonate hydroxide has been reported^{2,3} on zinc-coated/galvanised steel in marine environment. The complex being a protective one, would help in bringing down progressively the corrosion rate of zinc-coated/galvanised steel in marine atmosphere with increasing exposure time.

Theoretical attempts have been made earlier⁴ to mathematically describe the thickness-loss of galvanised coating in marine environment. The mathematical equation⁴ is:

$$TL = [\alpha \times C + \exp\{(b-E)/R \times T\}]t \quad \dots (1)$$

where, TL = thickness-loss due to corrosion, α = factor dependent mainly on the atmospheric chloride concentration, b = constant, E = activation energy of the atmospheric corrosion process, R = the gas constant (1.9872 cal/mole), T = temperature of the exposed galvanised structure/panel in absolute scale, t = the time of wetness of the panels (in years), C = concentration of atmospheric chloride (in $\mu\text{g}/\text{m}^3$).

To evaluate TL from this equation, it is required to find out by gravimetric method of chemical analysis the concentration of chloride in mass (μg) per unit volume (m^3) contained in the condensate/rain water collected from the concerned marine site. The concentration of atmospheric chloride is expressed as $\text{mg}/\text{m}^2/\text{day}$.

The purpose of the present attempt is to deduce a mathematical relationship with ' C ' expressed in terms of $\text{mg}/\text{m}^2/\text{day}$, based on some published data, to evaluate the galvanised coating thickness-loss of structural components installed in marine environment.

Now considering $b = 41.85$ and $E = 23240$ cal/mole as reported⁵, the factor $\exp\{(b-E)/RT\}$ is calculated to be 9.70×10^{-18} . This value is appreciably low for all practical purposes. Neglecting therefore the factor, and writing R_f (rainfall) in place of ' t ' Eq. (1) reduces to

$$TL = \alpha \times C \times R_f \quad \dots (2)$$

This on rearrangement yields

$$\alpha = TL/C \times R_f \quad \dots (3)$$

The α can be evaluated taking into account some published data⁶⁻⁸. Table 1 indicates average galvanised coating thickness-loss due to corrosion from two different severe marine atmospheric sites^{6,7}, with three different periods of exposure. The concentration of atmospheric chloride and rainfall, as extracted from a graphical representation⁸ of the Digha atmosphere at the Marine Corrosion Research

Table 1—Galvanised coating thickness-loss (TL) due to corrosion in severe marine atmospheric sites (refs 6, 7)

Exposure period (years)	Galvanised coating thickness-loss (μm)				TL (μm/y)
	Ref. 6		Ref. 7		
	Total loss	Loss/ year	Total loss	Loss/ year	
1	5.4	5.4	4.8	4.8	5.10
3	12.7	4.2	11.0	3.7	3.95
5	20.0	4.0	16.8	3.4	3.70
Average TL = 4.25					

Table 2—Atmospheric chloride and rainfall at Digha coast (ref. 8)

Month and year	Atmospheric chloride (C)		Rainfall (mm)
	mg/100 cm ² /day	mg/m ² /day	
Jan, 1976	0.8	80	0
Feb, '76	0.7	70	0
March, '76	1.3	130	0
April, '76	1.5	150	75
May, '76	1.5	150	108
June, '76	3.0	300	40
July, '76	1.3	130	228
Aug, '76	1.2	120	182
Sept, '76	0.4	40	315
Oct, '76	0.8	80	242
Nov, '76	0.7	70	40
Dec, '76	0.7	70	0
Average	1.16	116.08	3.37 mm per day 102.50 mm per month

Station (of NML) exposure site, has been approximated in Table 2. Now inserting average values of TL (from Table 1), C and R_f (from Table 2) into Eq. (3), α becomes

$$\alpha = 4.25/116.08 \times 3.37 = 1.086 \times 10^{-2}$$

Substituting the value of α so obtained, the approximate mathematical relationship for the evaluation of thickness-loss due to marine corrosion of galvanised steel structures/installations at the Digha coast of the bay of Bengal comes out as:

$$TL = 1.086 \times 10^{-2} \times C \times R_f$$

The mathematical relationship as worked out ($TL = 1.086 \times 10^{-2} \times C \times R_f$) in the present attempt, can be employed to evaluate approximately the thickness-loss ($\mu\text{m}/\text{y}$) of galvanised coated structures/installations due to marine atmospheric corrosion, provided the concentration of atmospheric chloride ($\text{mg}/\text{m}^2/\text{day}$) and rainfall (mm/day) at the exposure site are known.

References

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